

Q1. (a) Describe what happens to chromosomes in meiosis.

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(6)

(b) Meiosis results in genetic variation in the gametes which leads to variation in the offspring formed by sexual reproduction. Describe how meiosis causes this variation and explain the advantage of variation to the species.

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(5)

- (c) An old form of wheat, emmer wheat (*Triticum turgidum*), has a diploid chromosome number of 28 ($2n = 28$). A wild wheat, einkorn wheat (*Triticum tauschii*), has a diploid chromosome number of 14 ($2n = 14$). These two species occasionally crossed and produced sterile hybrid plants. Due to an error during cell division, one of these hybrid plants formed male and female gametes with 21 chromosomes. Fusion of these gametes resulted in viable offspring. These plants were a new species, *Triticum aestivum* ($2n = 42$), our modern bread wheat.

- (i) How many chromosomes would there have been in each of the cells of the hybrid plant produced by crossing *Triticum turgidum* with *Triticum tauschii*?

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- (ii) Explain why *Triticum aestivum* is fertile while the majority of hybrid plants were not.

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(3)

(Total 15 marks)

- Q2.** (a) The table shows the mRNA codons for some amino acids.

Codon	Amino acid
CUA	Leucine
GUC	Valine
ACG	Threonine
UGC	Cysteine
GCU	Alanine
AGU	Serine

- (i) Give the DNA sequence coding for cysteine.

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(1)

(ii) Name the amino acid coded by the tRNA anticodon UCA.

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(1)

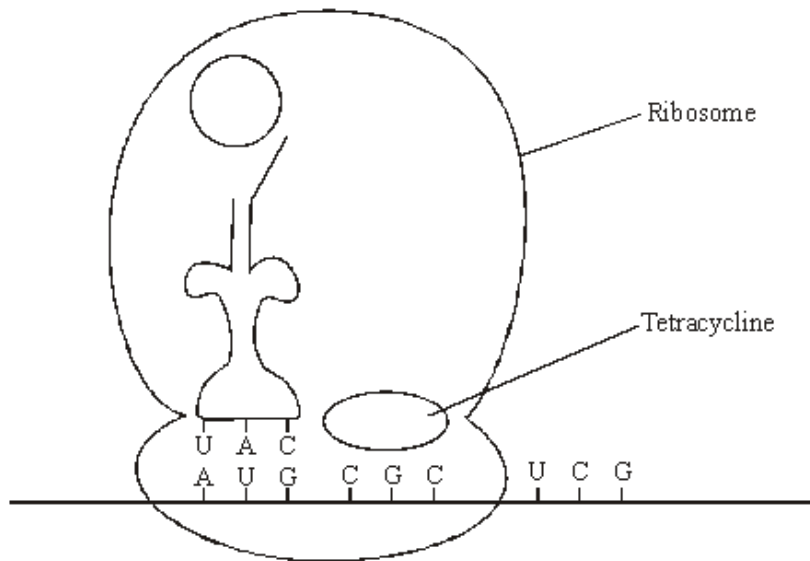
(b) A particular gene is 562 base-pairs long. However, the resulting mRNA is only 441 nucleotides long. Explain this difference.

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(1)

(c) Tetracycline binds to bacterial ribosomes. This is shown in the diagram.



Protein synthesis in bacteria is similar to that in eukaryotic cells. Explain how tetracycline stops protein synthesis.

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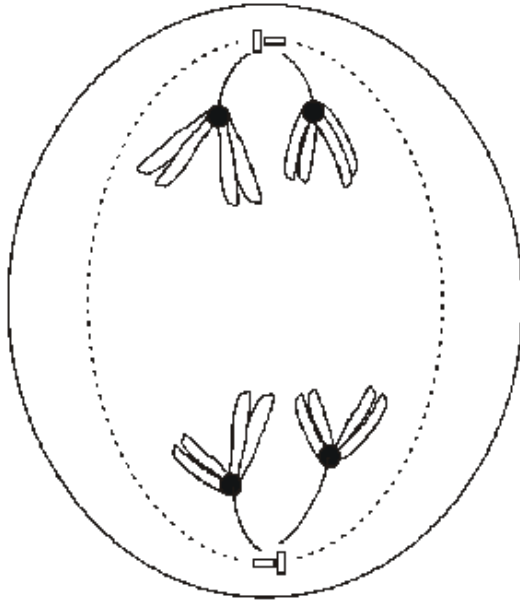
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(Total 5 marks)

- Q3.** (a) The diagram shows a cell undergoing cell division.



Identify the type and stage of cell division shown. Give evidence from the diagram to support your answer.

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- (b) Describe how crossing over occurs during meiosis I.

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(2)

(Total 5 marks)

Q4. (a) **Table 1** shows some of the events which take place in protein synthesis.

A	tRNA molecules bring specific amino acids to the mRNA molecule
B	mRNA nucleotides join with exposed DNA bases and form a molecule of mRNA
C	The two strands of a DNA molecule separate
D	Peptide bonds form between the amino acids
E	The mRNA molecule leaves the nucleus
F	A ribosome attaches to the mRNA molecule

Table 1

- (i) Write the letters in the correct order to show the sequence of events during protein synthesis, starting with the earliest.

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(2)

- (ii) In which part of a cell does **C** take place?

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(1)

- (iii) Which of **A - F** are involved in translation?

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(1)

- (b) **Table 2** shows some mRNA codons and the amino acids for which they code.

mRNA codon	Amino acid
GUU	Valine
CUU	Leucine
GCC	Alanine
AUU	Isoleucine
ACC	Threonine

Table 2

- (i) A tRNA molecule has the anticodon UAA. Which amino acid does the tRNA molecule carry?

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(1)

- (ii) Give the DNA base sequence that codes for threonine.

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(1)
(Total 6 marks)

Q5. Read the following passage.

- The sequence of bases in a molecule of DNA codes for proteins. Different sequences of bases code for different proteins. The genetic code, however, is degenerate. Although the base sequence AGT codes for serine, other sequences may also code for this same amino acid. There are four base sequences which code for the amino acid glycine. These are CCA, CCC, CCG and CCT. There are also four base sequences coding for the amino acid proline. These are GGA, GGC, GGG and GGT.

- Pieces of DNA which have a sequence where the same base is repeated many times are called “slippery”. When “slippery” DNA is copied during replication, errors may occur in copying. Individual bases may be copied more than once. This may give rise to differences in the protein which is produced by the piece of DNA containing the errors.

Use information in the passage and your own knowledge to answer the following questions.

- (a) Different sequences of bases code for different proteins (lines 1 – 2). Explain how.

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(2)

- (b) The base sequence AGT codes for serine (lines 2 – 3). Give the mRNA codon transcribed from this base sequence.

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(2)

- (c) Glycine-proline-proline is a series of amino acids found in a particular protein. Give the sequence of DNA bases for these three amino acids which contains the longest “slippery” sequence.

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(2)

- (d) (i) Explain how copying bases more than once may give rise to a difference in the protein (lines 9 – 10).

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(2)

(ii) At what stage in the cell cycle would these errors in copying DNA bases occur?

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(1)

(e) Starting with mRNA in the nucleus of a cell, describe how a molecule of protein is synthesised.

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(6)

(Total 15 marks)

- Q6.** (a) The table shows the mRNA codons for some amino acids.

Codon	Amino Acid
CUA	Leucine
GUC	Valine
ACG	Threonine
UGC	Cysteine
GCU	Alanine
AGU	Serine

- (i) Give the DNA sequence for cysteine.

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(1)

- (ii) Name the amino acid coded by the tRNA anticodon UCA.

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(1)

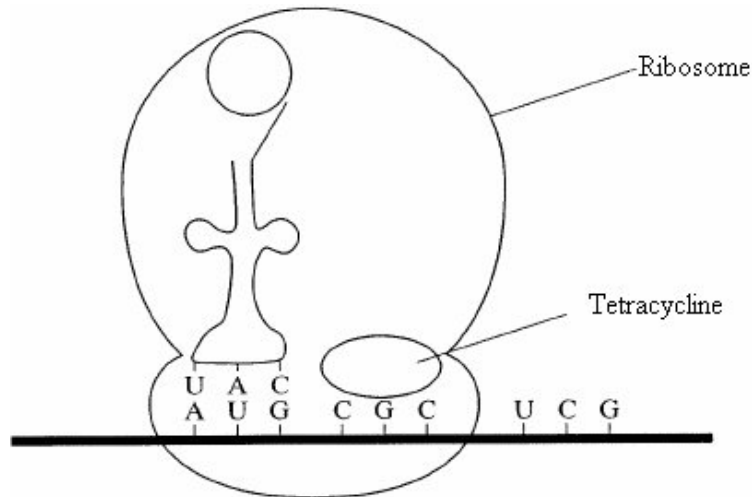
- (b) A particular gene is 652 base pairs long. The mRNA produced from this gene is only 441 nucleotides long. Explain this difference.

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(1)

- (c) Tetracycline is an antibiotic. The diagram shows how tetracycline binds to bacterial ribosomes.



Protein synthesis in bacteria is similar to that in eukaryotic cells. Explain how tetracycline stops protein synthesis in bacteria.

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(2)
(Total 5 marks)

Q7. The table shows the sequence of bases on part of the coding strand of DNA.

Base sequence on coding strand of DNA	C	G	T	T	A	C
Base sequence of mRNA						

- (a) Complete the table to show the base sequence of the mRNA transcribed from this DNA strand.

(2)

- (b) A piece of mRNA is 660 nucleotides long but the DNA coding strand from which it was transcribed is 870 nucleotides long.

- (i) Explain this difference in the number of nucleotides.

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(1)

- (ii) What is the maximum number of amino acids in the protein translated from this piece of mRNA? Explain your answer.

Number of amino acids

Explanation

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(2)

- (c) Complete the table to give **two** differences between the structure of mRNA and the structure of tRNA.

mRNA	tRNA

(2)

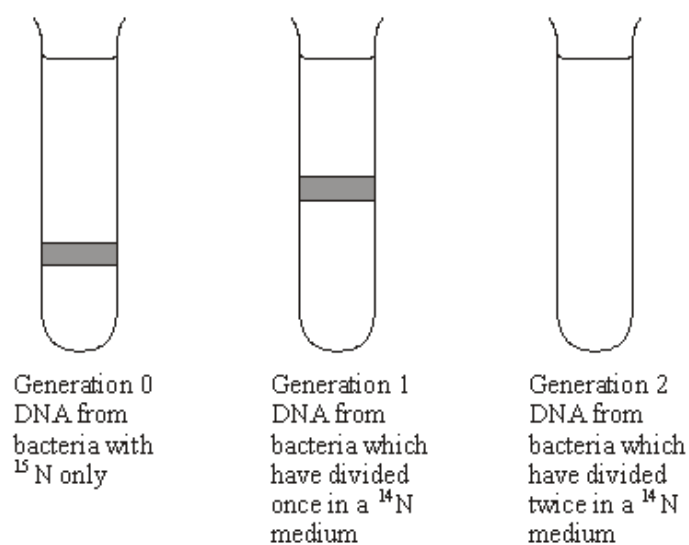
(Total 7 marks)

- Q8.** (a) There are two forms of nitrogen. These different forms are called isotopes. ^{15}N is a heavier isotope than the normal isotope ^{14}N .

In an investigation, a culture of bacteria was obtained in which all the nitrogen in the DNA was of the ^{15}N form. The bacteria (generation 0) were transferred to a medium containing only the normal isotope, ^{14}N , and allowed to divide once. A sample of these bacteria (generation 1) was then removed. The DNA in the bacteria of generation 1 was extracted and spun in a high-speed centrifuge.

The bacteria in the ^{14}N medium were allowed to divide one more time. The DNA was also extracted from these bacteria (generation 2) and spun in a high speed centrifuge.

The diagram shows the results of this investigation.



(i) Which part of the DNA molecule contains nitrogen?

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(1)

(ii) Explain why the DNA from generation 1 is found in the position shown.

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(2)

(iii) Complete the diagram to show the results for generation 2.

(2)

(b) The table shows the percentage of different bases in the DNA of different organisms.

Organism	Adenine%	Guanine%	Thymine%	Cytosine%
Human		19		
Bacterium	24	26	24	26
Virus	25	24	33	18

(i) Complete the table to show the percentages of different bases in human DNA.

(2)

- (ii) The structure of virus DNA is different from the DNA of the other two organisms. Giving evidence from the table, suggest what this difference might be.

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(2)
(Total 9 marks)

- Q9.** (a) What name is used for the non-coding sections of a gene?

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(1)

Figure 1 shows a DNA base sequence. It also shows the effect of two mutations on this base sequence. **Figure 2** shows DNA triplets that code for different amino acids.

Figure 1

Original DNA base sequence	A	T	T	G	G	C	G	T	G	T	C	T
Amino acid sequence												
Mutation 1 DNA base sequence	A	T	T	G	G	A	G	T	G	T	C	T
Mutation 2 DNA base sequence	A	T	T	G	G	C	C	T	G	T	C	T

Figure 2

DNA triplets	Amino acid
GGT, GGC, GGA, GGG	Gly
GTT, GTA, GTG, GTC	Val
ATC, ATT, ATA	Ile
TCC, TCT, TCA, TCG	Ser
CTC, CTT, CTA, CTG	Leu

- (b) Complete **Figure 1** to show the sequence of amino acids coded for by the original DNA base sequence.

(1)

(c) Some gene mutations affect the amino acid sequence. Some mutations do not. Use the information from **Figure 1** and **Figure 2** to explain

(i) whether mutation **1** affects the amino acid sequence

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(2)

(ii) how mutation **2** could lead to the formation of a non-functional enzyme.

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(3)

(d) Gene mutations occur spontaneously.

(i) During which part of the cell cycle are gene mutations most likely to occur?

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(1)

(ii) Suggest an explanation for your answer.

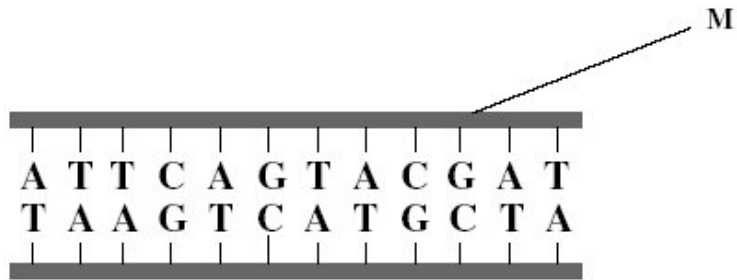
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(1)

(Total 9 marks)

Q10. The diagram shows part of a DNA molecule.



(a) Name the **two** components of the part of the DNA molecule labelled **M**.

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(2)

(b) What is the maximum number of amino acids for which this piece of DNA could code?

(1)

(c) Scientists calculated the percentage of different bases in the DNA from a species of bacterium. They found that 14% of the bases were guanine.

(i) What percentage of the bases in this species of bacterium was cytosine?

Answer

(1)

(ii) What percentage of the bases in this species of bacterium was adenine?

Answer

(1)

- (d) The scientists found that, in a second species of bacterium, 29% of the bases were guanine.

Explain the difference in the percentage of guanine bases in the two species of bacterium.

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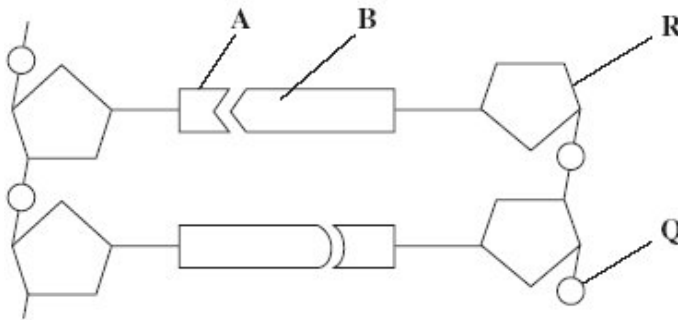
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(2)
(Total 7 marks)

Q11. **Figure 1** shows a short section of a DNA molecule.

Figure 1



- (a) Name parts **R** and **Q**.

- (i) **R**
- (ii) **Q**

(2)

- (b) Name the bonds that join **A** and **B**.

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(1)

- (c) Ribonuclease is an enzyme. It is 127 amino acids long.

What is the minimum number of DNA bases needed to code for ribonuclease?

(1)

- (d) **Figure 2** shows the sequence of DNA bases coding for seven amino acids in the enzyme ribonuclease.

Figure 2

G T T T A C T A C T C T T C T T C T T T A

The number of each type of amino acid coded for by this sequence of DNA bases is shown in the table.

Amino acid	Number present
Arg	3
Met	2
Gln	1
Asn	1

Use the table and **Figure 2** to work out the sequence of amino acids in this part of the enzyme. Write your answer in the boxes below.

Gln						
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(1)

- (e) Explain how a change in a sequence of DNA bases could result in a non-functional enzyme.

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(3)

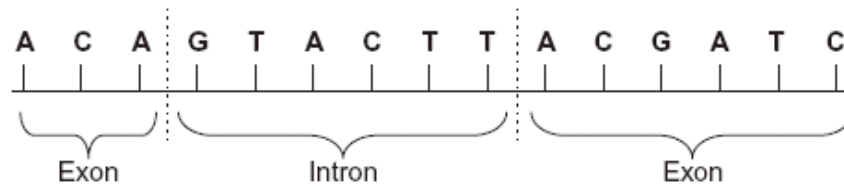
(Total 8 marks)

- Q12.** (a) Complete the table to show the differences between DNA, mRNA and tRNA.

Type of nucleic acid	Hydrogen bonds present (✓) or not present (✗)	Number of polynucleotide strands in molecule
DNA		
mRNA		
tRNA		

(2)

- (b) The diagram shows the bases on one strand of a piece of DNA.



- (i) In the space below, give the sequence of bases on the pre-mRNA transcribed from this strand.

(2)

- (ii) In the space below, give the sequence of bases on the mRNA produced by splicing this piece of pre-mRNA.

(1)
(Total 5 marks)

Q13. (a) DNA helicase is important in DNA replication. Explain why.

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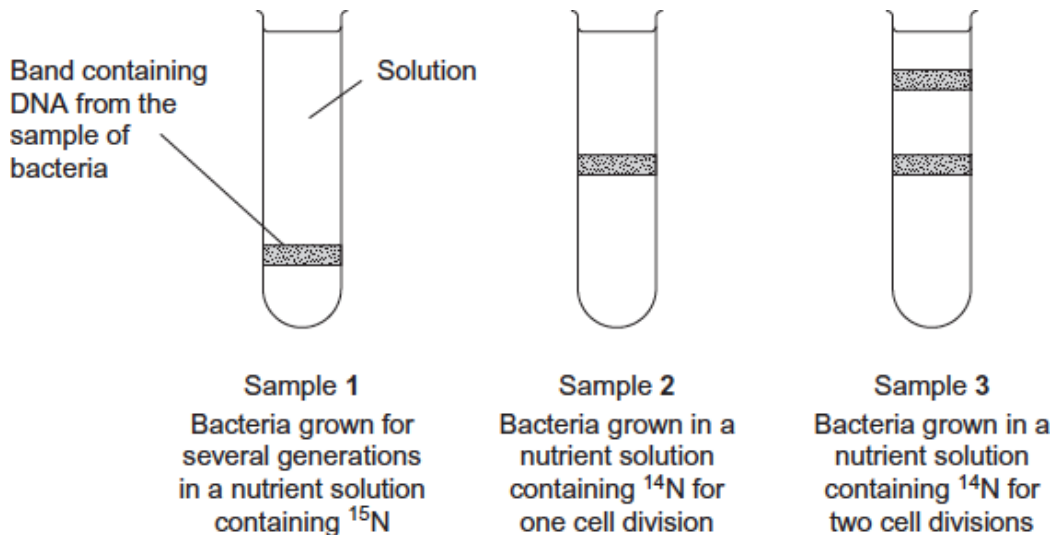
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Scientists investigating DNA replication grew bacteria for several generations in a nutrient solution containing a heavy form of nitrogen (^{15}N). They obtained DNA from a sample of these bacteria.

The scientists then transferred the bacteria to a nutrient solution containing a light form of nitrogen (^{14}N). The bacteria were allowed to grow and divide twice. After each division, DNA was obtained from a sample of bacteria.

The DNA from each sample of bacteria was suspended in a solution in separate tubes. These were spun in a centrifuge at the same speed and for the same time. The diagram shows the scientists' results.

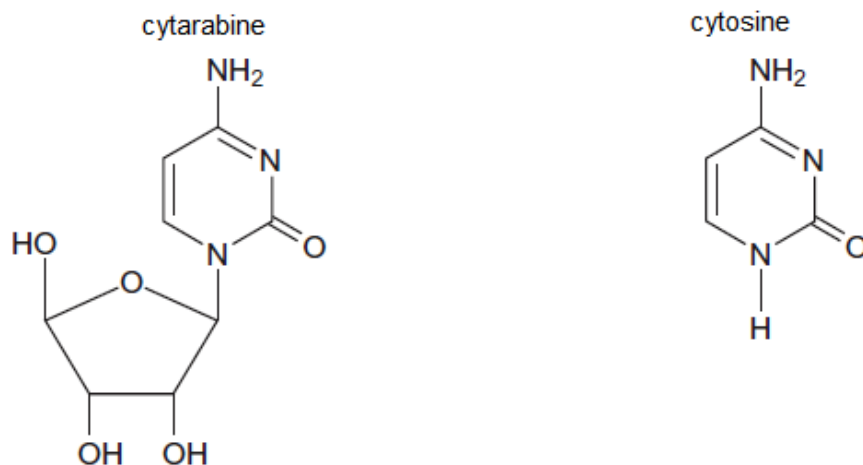


- (b) The table shows the types of DNA molecule that could be present in samples **1** to **3**. Use your knowledge of semi-conservative replication to complete the table with a tick if the DNA molecule is present in the sample.

Sample	Type(s) of DNA molecule present in each sample		
	¹⁵ N ¹⁵ N 	¹⁵ N ¹⁴ N 	¹⁴ N ¹⁴ N 
1			
2			
3			

(3)

- (c) Cytarabine is a drug used to treat certain cancers. It prevents DNA replication. The diagram shows the structures of cytarabine and the DNA base cytosine.



- (i) Use information in the diagram to suggest how cytarabine prevents DNA replication.

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(2)

- (ii) Cytarabine has a greater effect on cancer cells than on healthy cells. Explain why.

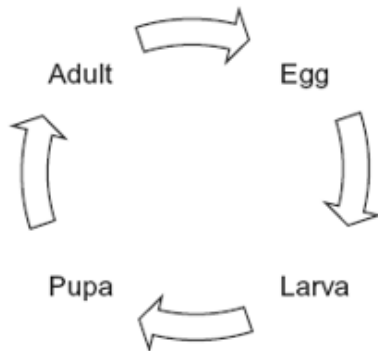
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(1)
(Total 8 marks)

- Q14.** The diagram shows the life cycle of a fly.



When the larva is fully grown, it changes into a pupa. The pupa does not feed. In the pupa, the tissues that made up the body of the larva are broken down. New adult tissues are formed from substances obtained from these broken-down tissues and from substances that were stored in the body of the larva.

- (a) Hydrolysis and condensation are important in the formation of new adult proteins. Explain how.

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(2)

- (b) Most of the protein stored in the body of a fly larva is a protein called calliphorin. Explain why different adult proteins can be made using calliphorin.

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(1)

The table shows the mean concentration of RNA in fly pupae at different ages.

Age of pupa as percentage of total time spent as a pupa	Mean concentration of RNA / μg per pupa
0	20
20	15
40	12
60	17
80	33
100	20

- (c) Describe how the concentration of RNA changes during the time spent as a pupa.

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(2)

- (d) (i) Describe how you would expect the number of lysosomes in a pupa to change with the age of the pupa. Give a reason for your answer.

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(2)

- (ii) Suggest an explanation for the change in RNA concentration in the first 40% of the time spent as a pupa.

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(2)

- (e) Suggest an explanation for the change in RNA concentration between 60 and 80% of the time spent as a pupa.

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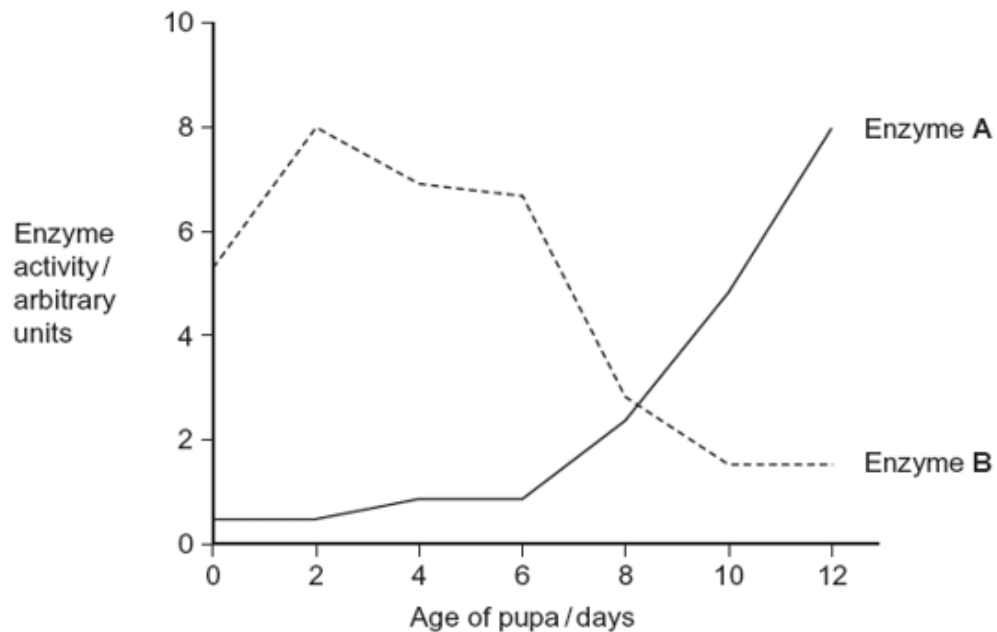
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(2)

- (f) The graph shows changes in the activity of two respiratory enzymes in a fly pupa.

- Enzyme **A** catalyses a reaction in the Krebs cycle
- Enzyme **B** catalyses the formation of lactate from pyruvate



During the first 6 days as a pupa, the tracheae break down. New tracheae are formed after 6 days. Use this information to explain the change in activity of the two enzymes.

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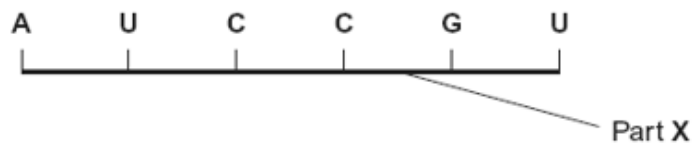
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(4)
(Total 15 marks)

Q15. The diagram shows part of a pre-mRNA molecule.



- (a) (i) Name the **two** substances that make up part **X**.
 and (1)
- (ii) Give the sequence of bases on the DNA strand from which this pre-mRNA has been transcribed.
 (1)
- (b) (i) Give one way in which the structure of an mRNA molecule is different from the structure of a tRNA molecule.

 (1)

- (ii) Explain the difference between pre-mRNA and mRNA.

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(1)

- (c) The table shows the percentage of different bases in two pre-mRNA molecules. The molecules were transcribed from the DNA in different parts of a chromosome.

Part of chromosome	Percentage of base			
	A	G	C	U
Middle	38	20	24	
End	31	22	26	

- (i) Complete the table by writing the percentage of uracil (U) in the appropriate boxes.

(1)

- (ii) Explain why the percentages of bases from the middle part of the chromosome and the end part are different.

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(2)

(Total 7 marks)

Q16. The diagram shows a short sequence of DNA bases.

TTTGTATACTAGTCTACTTCGTTAATA

- (a) (i) What is the maximum number of amino acids for which this sequence of DNA bases could code?

(1)

- (ii) The number of amino acids coded for could be fewer than your answer to part (a)(i).

Give **one** reason why.

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(1)

- (b) Explain how a change in the DNA base sequence for a protein may result in a change in the structure of the protein.

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(Extra space)

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(3)

- (c) A piece of DNA consisted of 74 base pairs. The two strands of the DNA, strands **A** and **B**, were analysed to find the **number** of bases of each type that were present. Some of the results are shown in the table.

	Number of bases			
	C	G	A	T
Strand A	26			
Strand B	19		9	

Complete the table by writing in the missing values.

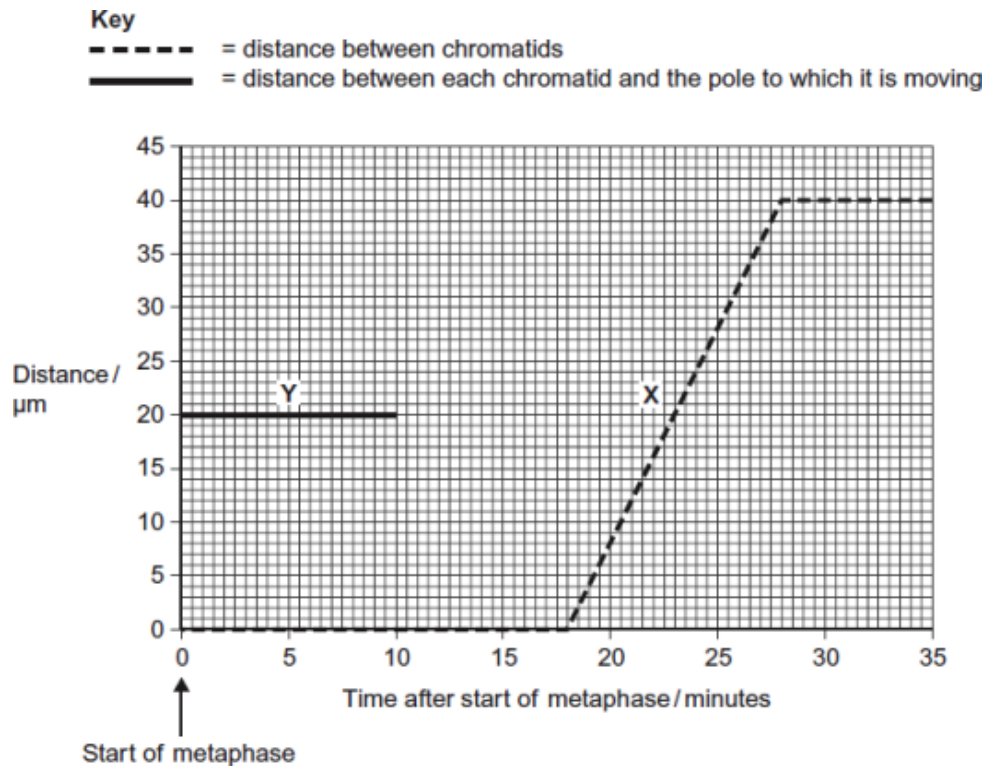
(2)

(Total 7 marks)

Q17. (a) Describe how DNA is replicated.

(6)

- (b) The graph shows information about the movement of chromatids in a cell that has just started metaphase of mitosis.



- (i) What was the duration of metaphase in this cell?

minutes

(1)

- (ii) Use line **X** to calculate the duration of anaphase in this cell.

minutes

(1)

- (iii) Complete line **Y** on the graph.

(2)

- (c) A doctor investigated the number of cells in different stages of the cell cycle in two tissue samples, **C** and **D**. One tissue sample was taken from a cancerous tumour. The other was taken from non-cancerous tissue. The table shows his results.

Stage of the cell cycle	Percentage of cells in each stage of the cell cycle	
	Tissue sample C	Tissue sample D
Interphase	82	45
Prophase	4	16
Metaphase	5	18
Anaphase	5	12
Telophase	4	9

- (i) In tissue sample **C**, one cell cycle took 24 hours. Use the data in the table to calculate the time in which these cells were in interphase during one cell cycle. Show your working.

Time cells in interphase hours

(2)

- (ii) Explain how the doctor could have recognised which cells were in interphase when looking at the tissue samples.

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(1)

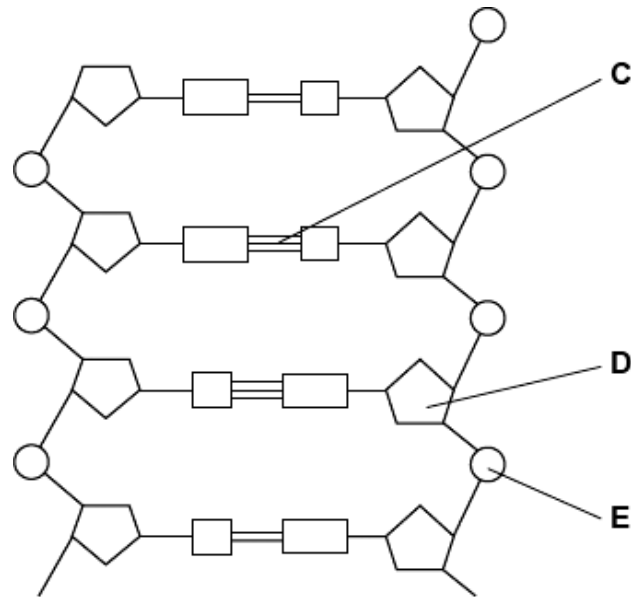
- (iii) Which tissue sample, **C** or **D**, was taken from a cancerous tumour? Use information in the table to explain your answer.

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(2)

(Total 15 marks)

Q18. The diagram shows part of a DNA molecule.



- (a) (i) DNA is a polymer. What is the evidence from the diagram that DNA is a polymer?

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(1)

- (ii) Name the parts of the diagram labelled **C**, **D** and **E**.

Part **C**

Part **D**

Part **E**

(3)

- (iii) In a piece of DNA, 34% of the bases were thymine.

Complete the table to show the names and percentages of the other bases.

Name of base	Percentage
Thymine	34
	34

(2)

(b) A polypeptide has 51 amino acids in its primary structure.

- (i) What is the minimum number of DNA bases required to code for the amino acids in this polypeptide?

(1)

- (ii) The gene for this polypeptide contains more than this number of bases.

Explain why

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(1)

(Total 8 marks)

Q19. The black mamba is a poisonous snake. Its poison contains a toxin.

The table shows the base sequence of mRNA that codes for the first two amino acids of this toxin.

Base sequence of anticodon on tRNA						
Base sequence of mRNA	A	C	G	A	U	G
Base sequence of DNA						

Complete the table to show

- (a) (i) the base sequence of the anticodon on the first tRNA molecule that would bind to this mRNA sequence

(1)

- (ii) the base sequence of the DNA from which this mRNA was transcribed.

(1)

- (b) The length of the section of DNA that codes for the complete toxin is longer than the mRNA used for translation. Explain why.

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(1)

- (c) A mutation in the base sequence of the DNA that codes for the toxin would change the base sequence of the mRNA.

Explain how a change in the base sequence of the mRNA could lead to a change in the tertiary structure of the toxin.

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(1)

- (d) The black mamba's toxin kills prey by preventing their breathing. It does this by inhibiting the enzyme acetylcholinesterase at neuromuscular junctions. Explain how this prevents breathing.

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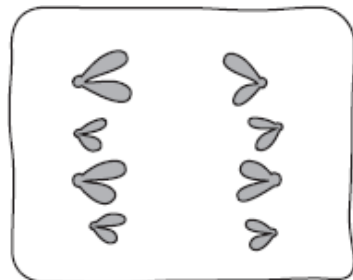
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(3)

(Total 7 marks)

- Q20.** (a) The diagram shows a stage of mitosis in an animal cell.



- (i) Name this stage.

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(1)

- (ii) Describe what happens during this stage that results in the production of two genetically identical cells.

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(2)

- (b) A sample of epithelial tissue from the small intestine of an animal was analysed. Some of the cells had 8.4 units of DNA, others had only 4.2 units.

- (i) Use your knowledge of the cell cycle to explain why some cells had 8.4 units of DNA and others had only 4.2 units.

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(2)

- (ii) How many units of DNA would you expect to be present in a gamete formed in this animal as a result of meiosis?

(1)

(Total 6 marks)

- Q21.** Phenylketonuria is a disease caused by mutations of the gene coding for the enzyme PAH. The table shows part of the DNA base sequence coding for PAH. It also shows a mutation of this sequence which leads to the production of non-functioning PAH.

DNA base sequence coding for PAH	C	A	G	T	T	C	G	C	T	A	C	G
DNA base sequence coding for non-functioning PAH	C	A	G	T	T	C	C	C	T	A	C	G

- (a) (i) What is the maximum number of amino acids for which this base sequence could code?

(1)

- (ii) Explain how this mutation leads to the formation of non-functioning PAH.

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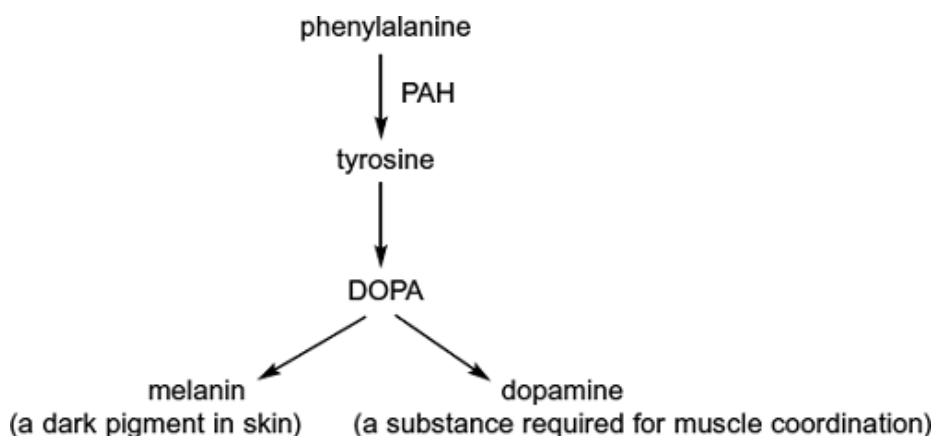
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(3)

PAH catalyses a reaction at the start of two enzyme-controlled pathways. The diagram shows these pathways.



- (b) Use the information in the diagram to give **two** symptoms you might expect to be visible in a person who produces non-functioning PAH.

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2

(2)

- (c) One mutation causing phenylketonuria was originally only found in one population in central Asia. It is now found in many different populations across Asia. Suggest how the spread of this mutation may have occurred.

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(1)

- M1.** (a) 1. Chromosomes shorten/thicken/condense;
 2. Chromosomes associate in homologous/(described) pairs / formation of bivalents / tetrads;
 3. Crossing-over / chiasma formation;
 4. Join to spindle (fibres) / moved by spindle;(*)
 5. (At) equator/middle of cell;(*)
 6. (join via) centromere / kinetochore;(*)
 7. (Homologous) chromosomes move to opposite poles / chromosomes separate/move apart; (*ALLOW* 'are pulled apart')
 8. (Pairs of) chromatids separated in 2nd division;
 (*) OR "independent assortment"
 unqualified = 1 mark

max 6

- (b) 1. Crossing-over; [*IGNORE* any wrong ref. to timing]
 2. Independent/random assortment/orientation/segregation of (homologous) chromosomes in meiosis I;
 3. Independent/random assortment/orientation/segregation of chromatids in meiosis II;
 + Any **three** from:
 4. Different adaptations / some better adapted;
 5. Some survive / example described;
 6. To reproduce;
 7. Pass on gene/allele;
 8. Allows for changing environment/different environment/example described;

max 5

- (c) (i) 21;

1

- (ii) 1. *T. aestivum* has 2 copies of each type of chromosome/is diploid;
 2. *T. aestivum*'s chromosomes can form bivalents/can assort in meiosis/ can produce haploid gametes;
 3. *T. aestivum*'s gametes receive a copy of every chromosome/ receive all the genetic information;
ACCEPT converse argument for hybrid plants

3

[15]

- M2.** (a) (i) ACG;

1

- (ii) serine;

1

- (b) idea that DNA contains introns/ mRNA is only exons/ mRNA is “edited”;
(allow junk/ non-sense DNA)

1

- (c) translation cannot occur; binds to/blocks codon/ triplet on mRNA;
anticodon/tRNA will not fit in/base-pair; amino acids not
delivered/ joined;

2 max

[5]

- M3.** (a) (meiosis) anaphase I;
chromosomes are moving apart;
chromosomes still double structures;

3

- (b) chromosomes in each (homologous) pair twist around each other;
chromatids break and rejoin to chromatid on sister chromosome;
(accept points from a suitable diagram)

2

[5]

- M4.** (a) (i) $C \rightarrow B \rightarrow E \rightarrow F \rightarrow A \rightarrow D$

Mark links: 5 correct = 2, 4 correct = 1, <4 correct = 0

2

- (iii) nucleus;

1

- (iii) A, D, F; (ignore E if evident)

1

- (b) (i) Isoleucine;

1

- (ii) TGG;

1

[6]

- M5.** (a) Protein made of (chain of) amino acids;
Each amino acid has its own base code/code;
Triplet codes;

max 2

- (b) UCA = 2 marks
TCA – 1 mark;
2
- (c) CCG;
GGG GGG;
2
- (d) (i) Changes base sequence;
Of later triplets/amino acid codes;
2
- (ii) S-phase/interphase;
1
- (e) 1. mRNA leaves (nucleus) through nuclear pore;
2. To ribosome;
3. tRNA molecules bring amino acids (to ribosome);
4. Specific tRNA molecule for specific amino acid;
5. Anticodon of tRNA corresponds / complementary to codon on mRNA;
6. Peptide bonds form between amino acids;
7. tRNA detaches and collects another amino acid;
8. Ribosome moves along mRNA;
max 6

[15]

- M6.** (a) (i) ACG;
1
- (ii) Serine;
1
- (b) DNA contains introns / (pre) mRNA is edited;
1
- (c) (Tetracycline) binds to/blocks mRNA triplet;
Anticodon/tRNA triplet cannot pair with mRNA triplet;
Amino acid not added to polypeptide chain;
Translation prevented;
2 max

[5]

M7.	(a) GCAAUG; ; <i>Allow one mark if T instead of U, i.e. GCAATG</i>	2	[7]
	(b) (i) DNA is edited/introns present in DNA; <i>Allow reference to 'junk' or non-coding DNA</i>	1	
	(ii) 220; allow 218 or 219-allow 2 Three bases/nucleotides code for one amino acid; Correct explanation for 218 or 219;	2	
	(c) mRNA has no base-pairing, tRNA has base-pairing/ mRNA linear, tRNA cloverleaf shape; mRNA has no binding site for amino acids, tRNA has; mRNA different for each gene/many kinds, only few/20/64 kinds of tRNA; accept mRNA longer/larger/more nucleotides than tRNA	max 2	
M8.	(a) (i) base / named bases; <i>reject nucleotide or uracil</i>	1	[9]
	(ii) it has been produced by semi-conservative replication / one old strand and one new; one strand has ¹⁵ N bases and the other ¹⁴ N; <i>Accept light/ heavy N (therefore) it is less dense / lighter;</i>	2 max	
	(iii) one band is in same position as generation 1; one band higher; <i>accept a line. N.B. need a visible gap</i>	2	
	(b) (i) A = 31 and JT = 31; C = 19; (ii) viral DNA single-stranded / not double-stranded; evidence from table e.g. not equal amount of A and T / C and G / all different; <i>ignore no base-pairing In this Question assume It' means viral DNA</i>	2 2	
M9.	(a) Introns;	1	
	(b) Ile Gly Val Ser;	1	

- (c) (i) Has no effect/same amino acid (sequence)/same primary structure;
Q Reject same amino acid formed or produced.
 1
- Glycine named as same amino acid;
 1
- It still codes for glycine = two marks.*
- (ii) Leu replaces Val/change in amino acid (sequence)/primary structure;
 Change in hydrogen/ionic bonds;
Q Different amino acid formed or produced negates first marking point.
 Alters tertiary structure/active site;
 Substrate cannot bind/no longer complementary/
 no enzyme-substrate complexes form;
Active site changed must be clear for third marking point but does not need reference to shape.
 3 max
- (d) (i) Interphase/S/synthesis (phase);
 1
- (ii) DNA/gene replication/synthesis occurs/longest stage;
Allow 'genetic information' = DNA.
Allow 'copied' or 'formed' = replication/synthesis
 1

[9]

- M10.** (a) Phosphate;
 Deoxyribose;
Q Candidates must specify deoxyribose. This term is a specification requirement.
Ignore anything that is not incorrect.
 2
- (b) 4;
 1
- (c) (i) 14;
 1
- (ii) 36;
If (c)(i) incorrect accept [50 – (c)(i)]
 1

- (d) Different proteins;
Different genes;
Different (DNA) base sequences;

2 max

[7]

- M11.** (a) (i) Deoxyribose;
pentose/5C sugar = neutral

1

- (ii) Phosphate/Phosphoric acid;
phosphorus/P = neutral

1

- (b) Hydrogen (bonds);

1

- (c) 381/384/387;

1

- (d) (Gln) Met Met Arg Arg Arg Asn;

1

- (e) Change in (sequence of) amino acids/primary structure;
Change in hydrogen/ionic/disulfide bonds;
Alters tertiary structure/active site (of enzyme);
Substrate cannot bind/no enzyme-substrate complexes form;
Q Reject = different amino acids are formed

3 max

[8]

- M12.** (a)

DNA	✓	2
mRNA	✗	1
tRNA	✓	1

*One mark for each correct column
Regard blank as incorrect in the context of this question
Accept numbers written out: two, one, one*

2

- (b) (i) Marking principles
1 mark for complete piece transcribed;
Correct answer
UGU CAU GAA UGC UAG
- 1 mark for complementary bases from sequence transcribed;
but allow 1 mark for complementary bases from section transcribed, providing all four bases are involved

2

- (ii) Marking principle
1 mark for bases corresponding to exons taken from (b)(i)
Correct answer
UGU UGC UAG
If sequence is incorrect in (b)(i), award mark if section is from exons. Ignore gaps.

1

[5]

- M13.** (a) 1. Separates / unwinds / unzips strands / helix / breaks H-bonds;
1. Q Neutral: strands / helix split
1. Accept: unzips bases
2. (So) nucleotides can attach / are attracted / strands can act as templates;
2. Q Neutral: bases can attach
2. Neutral: helix can act as a template

2

(b)

Sample	Type(s) of DNA molecule present in each tube		
	$^{15}\text{N}/^{15}\text{N}$	$^{15}\text{N}/^{14}\text{N}$	$^{14}\text{N}/^{14}\text{N}$
1	✓		
2		✓	
3		✓	✓

One mark for each correct row

3

- (c) (i) 1. Similar shape / structure (to cytosine) / added instead of cytosine / binds to guanine;
 1. *Accept: idea that only one group is different*
 1. *Reject: same shape*
2. Prevents (complementary) base pairing / prevents H-bonds forming / prevents formation of new strand / prevents strand elongation / inhibits/binds to (DNA) polymerase;
 2. *Accept: prevents cytosine binding*
Neutral: 'prevents DNA replication' as given in the question stem
Neutral: 'competitive inhibitor' unqualified
Neutral: inhibits DNA helicase
- (ii) (Cancer cells / DNA) divide / replicate fast(er) / uncontrollably;
Accept: converse argument for healthy cells

2

1

[8]

- M14.** (a) 1. Hydrolysis breaks proteins / hydrolyses proteins / produces amino acids (from proteins);
2. Protein synthesis involves condensation;
3. Hydrolysis of polysaccharides/lipids linked to energy source (for synthesising proteins);
Do not award any credit if hydrolysis and condensation confused.
 3. *Accept hydrolysis of other molecules if related to protein synthesis.*

2 max

- (b) Amino acids (from calliphorin) can be joined in different sequences/ rearranged;

1

- (c) 1. Fall, rise and fall;
2. Rise after 40 and fall after 80;
Ignore concentration values.

2

- (d) (i) Fall / increase then fall;
- Lysosomes associated with tissue breakdown;

2

- (ii) 1. Tissues/cells are being broken down;
2. RNA is digested/hydrolysed/broken down;
3. By enzymes from lysosomes;
4. New proteins not made / no new RNA made;

2 max

(e) 1. (RNA) associated with making protein;

2. New / adult tissues are forming;

2

(f) 1. In the first 6 days no/little oxygen supplied / with breakdown of tracheae, no/little oxygen supplied;

2. (Without tracheae) respire anaerobically;

3. Anaerobic respiration involves reactions catalysed by enzyme **B** / conversion of pyruvate to lactate/involves lactate production;

4. Enzyme **A**/Krebs cycle is part of aerobic respiration;

Or, with emphasis on aerobic respiration:

1. Tracheae supply oxygen / after 6 days oxygen supplied;

2. (With tracheae) tissues can respire aerobically.

4

[15]

M15. (a) (i) Phosphate and ribose;

Accept in either order. Both correct for one mark.

For phosphate accept PO_4 / Pi / \textcircled{P} but not P .

Do not accept phosphorus.

Ignore references to pentose / sugar.

1

(ii) TAGGCA;

1

(b) (i) Does not contain hydrogen bonds/base pairs /contains codons / does not contain anticodon / straight/not folded / no amino acid binding site/longer;

Assume that "it" refers to mRNA.

Do not accept double stranded.

1

(ii) (pre-mRNA) contains introns / mRNA contains only exons;

Assume that "it" refers to pre-mRNA.

Accept non-coding as equivalent to intron.

1

(c) (i)

Part of chromosome	U
Middle	18
End	21

One mark for both figures correct

1

- (ii) 1. Different genes;
 2. Have different (base) sequences / combinations of (bases);
 3. (Pre-mRNA) transcribed from different DNA/codes for different proteins;
Note this question is not about the position of bases on genes.
 1. Telomere on end is equivalent.

2 max

[7]

M16. (a) (i) 9;
Accept: nine

1

- (ii) Introns / non-coding DNA / junk DNA;
 Start/stop code/triplet;
Neutral: Repeats.
Accept: 'Introns and exons present'.
Reject: 'Due to exons'.

1 max

- (b) Change in amino acid/s /primary structure;
 Change in hydrogen/ionic/ disulfide bonds;
 Alters tertiary structure;
Reject: 'Different amino acid is formed' – negates first marking point.
Neutral: Reference to active site.

3

- (c) Number of bases

	Number of bases			
	C	G	A	T
Strand A	26	19	20	9
Strand B	19	26	9	20

Second column correct;

Columns three and four correct;

2

[7]

- M17.**
- (a) 1. Strands separate / H-bonds break;
 1. *Q Neutral: strands split*
 1. *Accept: strands unzip*
2. DNA helicase (involved);
3. Both strands / each strand act(s) as (a) template(s);
4. (Free) nucleotides attach;
 4. *Neutral: bases attach*
 4. *Accept: nucleotides attracted*
5. Complementary / specific base pairing / AT and GC;
6. DNA polymerase joins nucleotides (on new strand);
 6. *Reject: if wrong function of DNA polymerase*
7. H-bonds reform;
8. Semi-conservative replication / new DNA molecules contain one old strand and one new strand;
 8. *Reject: if wrong context e.g. new DNA molecules contain half of each original strand*
- 6 max**
- (b) (i) 18;
 Do not accept 17.5
- 1**
- (ii) 10;
- 1**
- (iii) 1. Horizontal until 18 minutes;
 Allow +/- one small box
2. (Then) decreases as straight line to 0 μm at 28 minutes;
 2. *Allow lines that start from the wrong place, ending at 0 at 28 minutes*
- 2**
- (c) (i) Two marks for correct answer of 19.68 or 19.7;;
 Accept 19hrs 41mins
- One mark for incorrect answers in which candidate clearly multiplies by 0.82;
 Allow one mark for incorrect answers that clearly show 82% of 24 (hours)
- 2**
- (ii) 1. No visible chromosomes / chromatids;
2. Visible nucleus;
- 1 max**

(iii) **D** (no mark)

1. Lower % (of cells) in interphase / higher % (of cells) in mitosis / named stage of mitosis;
1. Accept: 'less' or 'more' instead of '%'
1. Do not accept: higher % (of cells) in each / all stage(s)
2. (So) more cells dividing / cells are dividing quicker;
2. Accept: uncontrolled cell division
*2. Do not award if Tissue **C** is chosen*

2

[15]

- M18.** (a) (i) Repeating units / nucleotides / monomer / molecules;
Allow more than one, but reject two

1

- (ii)
1. C = hydrogen bonds;
 2. D = deoxyribose;
2. Ignore sugar
 3. E = phosphate;
3. Ignore phosphorus, Ignore molecule

3

(iii)

Name of base	Percentage
Thymine	34
Cytosine / Guanine	16
Adenine	34
Cytosine / Guanine	16

Spelling must be correct to gain MP1

First mark = names correct

Second mark = % correct, with adenine as 34%

2

- (b) (i) 153;

1

- (ii) Some regions of the gene are non-coding / introns / start / stop code / triplet / there are two DNA strands;

Allow addition mutation

Ignore unqualified reference to mutation

Accept reference to introns and exons if given together

Ignore 'junk' DNA / multiple repeats

1

[8]

M19. (a) (i) UGC;

1

(ii) TGCTAC;

1

- (b) (DNA) contains introns / non-coding bases / mRNA only contains exons / coding bases;

Assume that 'it' refers to DNA

Neutral: DNA contains introns and exons

Neutral: 'splicing'

Neutral: pre-mRNA contains introns

Ignore refs. to start and stop codons

1

- (c) Different primary structure / amino acid sequence / amino acid coded for;

Reject: different amino acids produced / formed

Neutral: refs. to bonds

1

- (d) 1. Acetylcholine not broken down / stays bound to receptor;
2. Na⁺ ions (continue to) enter / (continued) depolarisation / Na⁺ channels (kept) open / action potentials / impulses fired (continuously);
3. (Intercostal) muscles stay contracted / cannot relax;
3. *'Muscles contract' is not enough*
- Accept: diaphragm stays contracted / cannot relax*

3

[7]

M20. (a) (i) Anaphase

1

- (ii) 1. Sister / identical chromatids / identical chromosomes;
1. *Reject: Homologous chromosomes separate.*
1. *Allow any reference to chromatids / chromosomes being identical e.g. same DNA*
2. To (opposite) poles / ends / sides;

2

- (b) (i) 1. 8.4 / cells with twice DNA content = replicated DNA / late interphase / prophase / metaphase / anaphase;
 1. *Any reference to interphase must suggest towards end of interphase.*
 1. *'Chromosomes replicate' is not enough for DNA replicates.*
2. 4.2 = DNA not replicated / (early) interphase / telophase / cell just divided / finished mitosis;
- 2
- (ii) 2.1;
- 1
- [6]

- M21.** (a) (i) 4;
- 1
- (ii) 1. Change in amino acid / (sequence of) amino acids / primary structure;
 1. *Reject = different amino acids are 'formed'*
2. Change in hydrogen / ionic / disulphide bonds;
3. Alters tertiary structure / active site (of enzyme);
 3. *Alters 3D structure on its own is not enough for this marking point.*
4. Substrate not complementary / cannot bind (to enzyme / active site) / no enzyme- substrate complexes form;
- 3 max
- (b) 1. Lack of skin pigment / pale / light skin / albino;
2. Lack of coordination / muscles action affected;
- 2 max
- (c) Founder effect / colonies split off / migration / interbreeding;
Allow description of interbreeding e.g. reproduction between individuals from different populations
- 1
- [7]

